(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 667 501 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 95102050.2

(22) Date of filing: 15.02.95

(51) Int. Cl.[6]: F25D 3/11, A23L 3/36, A23L 3/375

(30) Priority: 15.02.94 GB 9402884

(43) Date of publication of application: 16.08.95 Bulletin 95/33

(84) Designated Contracting States: DE FR GB

(71) Applicant: AIR PRODUCTS AND CHEMICALS, INC.
7201 Hamilton Boulevard
Allentown, PA 18195-1501 (US)

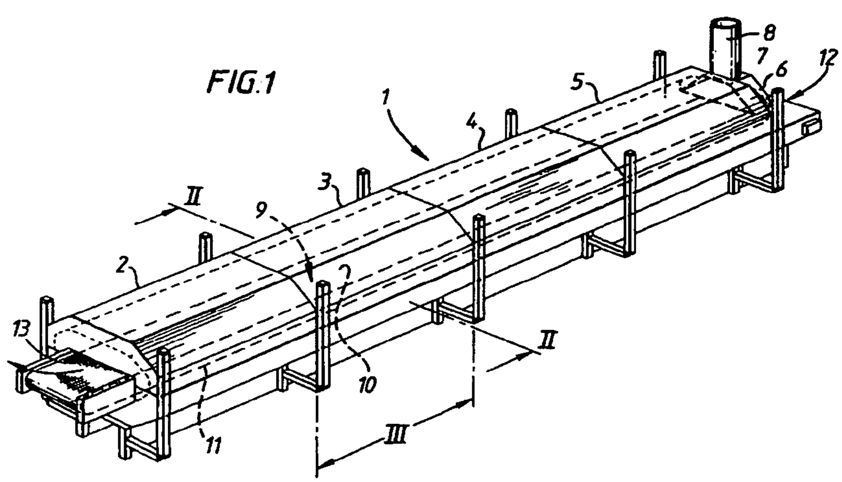
(72) Inventor: Miller, Jeremy Paul
Caxton House,
Victoria Road,
Mortimer
Nr. Reading RG7 3SL,
Berkshire (GB)
Inventor: Wilyman, Peter Robert
214 Little Marlow Road
Marlow,
Buckinghamshire SL7 1HX (GB)

(74) Representative: Lucas, Brian Ronald
Lucas & Co.
135 Westhall Road
Warlingham
Surrey CR6 9HJ (GB)

(54) Tunnel freezer.

(57) Means (35) are provided to adjust the speed of the turbulence inducing fans (21, 32) in a tunnel freezer (1) in accordance with the product to be cooled and/or frozen. In one embodiment the tunnel freezer (1) comprises four sections (2,3,4,5) each of which is maintained at a specific temperature by its own temperature sensor (26) and its own supply of cryogenic fluid (27,29,30). Each section (2,3,4,5) is provided with one or more turbulence inducing fans (21,32) the speed of which is adjusted in accordance with the product to be cooled and/or frozen. The tunnel freezer (1) may also be provided with one or more gas transfer fans.

FIG.1



EP 0 667 501 A1

This invention relates to a tunnel freezer.

Background of the Invention

Tunnel freezers generally comprise an elongate tunnel having a product inlet and a product outlet. A conveyor is arranged to transport product through the tunnel in counter-current flow to a stream of cryogenic fluid which is introduced, typically as liquid, from a spray bar adjacent the product outlet and exists via an exhaust duct adjacent the product inlet.

The tunnel itself generally contains two types of fan, viz:-

1. Gas transfer fans; and
2. Turbulence inducing fans.

The gas transfer fans generally resemble hair dryers and suck cryogenic vapour upwardly from the conveyor and blow it along the elongate tunnel towards the exhaust duct.

In contrast, the turbulence inducing fans are designed to circulate gas to enhance heat transfer to the product on the conveyor. Typically, gas will leave turbulence inducing fans in all directions, i.e. with no net movement along the elongate tunnel. Occasionally, diverters are provided to direct gas leaving the turbulence inducing fans towards the sides of the tunnel, i.e. to inhibit movement of gas towards the exhaust duct.

Typically, a 10m long tunnel will include 1 or 2 gas transfer fans and from 10 to 20 turbulence inducing fans.

At the present time turbulence inducing fans are driven at a fixed speed.

We have discovered that, for certain products, for example turkeys, chicken and gateaux, the speed of the turbulence inducing fans can be very much reduced without materially affecting the overall time taken for the product to freeze throughout. By reducing the speed of the turbulence inducing fans the overall power consumption of the tunnel freezer is reduced. In addition, since less work is performed by the turbulence inducing fans on the cryogenic vapour in the tunnel freezer the cryogenic vapour remains colder and less is needed.

According to the present invention there is provided a tunnel freezer having at least one turbulence inducing fan and means to drive said turbulence inducing fan, characterized in that said tunnel freezer further comprises means to vary the output of said turbulence inducing fan.

The output of the fan will generally be varied by adjusting its speed. However, it is conceivable that it could be adjusted by varying the pitch of the blades. For convenience references herein to adjusting the speed of the turbulence inducing fan include adjusting the pitch of the blades.

Preferably, said means is capable of reducing the speed of said turbulence inducing fan(s) to about 50%, more preferably 30%, advantageously 20% and more advantageously 5% of its normal operating speed.

Our initial experiments have indicated that each product must be individually tested. This can be achieved by inserting a thermocouple in the centre of the product and measuring the time taken for the desired temperature to be reached with different turbulence inducing fan speeds.

At the moment the main factor appears to be the speed at which a cold front will move across the product and the thickness of the product. At one extreme a thin hamburger will cool throughout extremely rapidly. At the other extreme, the stuffing in a large turkey will take several hours to freeze almost independent of the speed of the turbulence inducing fans until the speed of the turbulence inducing fans is reduced to below 20% of its normal operating speed.

Advantageously, a control unit will be provided which will be programmed with turbulence inducing fan speeds suitable for use with a particular product. In use, when it is desired to cool/freeze a particular product the operator will simply press a button corresponding to the product and the turbulence inducing fan speed appropriate to that product will automatically be selected.

If it is intended to freeze batches of different items where the thickness may be different, for example a batch of small gateaux about 100mm high followed by a batch of large gateaux with a height of about 150mm a height gauge may be placed adjacent the product inlet of the tunnel.

When the batch of small gateaux is being frozen a turbulence inducing fan speed of about 75% normal operating speed may be appropriate whilst when the batch of large gateaux is being frozen the height gauge automatically reduces the speed of the turbulence inducing fans by 50%. Low turbulence inducing fan speeds are also appropriate for freezing foodstuffs in cardboard cartons, for example pre-prepared meals.

Conventionally, the amount of liquid nitrogen supplied to a tunnel freezer is controlled so that temperature at a temperature sensor in the tunnel freezer remains substantially constant. The location of the temperature sensor varies from manufacturer to manufacturer but is usually either midway along the tunnel freezer or offset towards the liquid nitrogen supply. Whilst this arrangement is quite satisfactory for freezing products such as hamburgers at the rated capacity of the freezing tunnel various problems arise with thick products and those which are insulated, for example precooked meals in cardboard boxes. In these cases, although the temperature at the temperature sensor may be correct

the temperature in the exhaust duct can be very low due to the low total heat transfer between the cold nitrogen vapour and the insulated product.

According to the present invention the speed of the turbulence inducing fans can be individually adjusted to provide heat transfer at a rate compatible with the maximum rate at which the product can be frozen.

Whilst suitable speeds for the turbulence inducing fans can be found for steady state operation, i.e. when the flow of product to be frozen is uniform this is rarely the case in practice.

In a radical departure from existing tunnel freezers the present invention proposes a tunnel freezer having two or more sections each of which is provided with at least one turbulence inducing fan and each of which is also provided with a temperature sensor and means for supplying cryogenic fluid to said section in response to the temperature in said section.

In use, each section is operated at a substantially constant predetermined temperature whilst the speed of the turbulence inducing fan(s) in the section is varied in accordance with the product to be frozen, e.g. rated speed for hamburgers, 20% of rated speed for large turkeys.

It is anticipated that one tunnel freezer in accordance with the invention will have four sections with temperatures of -40°C±5°C, -73°C±5°C, -107°C±5°C, and -140°C±5°C respectively, the warmest section being adjacent the exhaust duct.

In this case the speed of the turbulence inducing fan(s) in each section is varied according to the product to be frozen. Typically, if the tunnel freezer is idle, the speed of the turbulence inducing fans could be reduced to about 5% of their rated speed. This is sufficient to avoid excessive stratification of the cold nitrogen vapour within the tunnel freezer whilst providing minimal heat input.

If a product such as a hamburger is introduced into the freezer, i.e. a product which is thin, small and can readily be frozen, the turbulence inducing fans are rotated at their rated value. However, if the product to be frozen is a thick gateaux the speed of the turbulence inducing fans is adjusted to the point where additional rotational speed would not materially increase the total time to cool the product.

Generally, the temperature to which foodstuffs should be frozen is in the range -15°C to -25°.

In a fully automated system a controller is advised that the product should emerge from the tunnel freezer at -20°C. An infra-red camera is positioned adjacent the product outlet. The temperature of the frozen product is then sensed. If it is colder than -20°C a control signal automatically reduces the speed of the turbulence inducing fans. If the temperature is -20°C then the speed of the turbulence inducing fans is then reduced in small increments until the temperature of the product rises slightly at which time the speed of the turbulence inducing fan is increased slightly. It should be noted that reducing the speed of the turbulence inducing fans does not necessarily mean that the product will be warmer as explained hereinbefore.

In conventional tunnel freezers the user is free to adjust the set point of the temperature sensor in his freezer. This can be extremely wasteful since normally a reduction of the set point results in a corresponding drop in temperature in the exhaust gas - which is very wasteful.

In preferred embodiments of the invention the temperature in each section is determined by a non-adjustable pre-programmed chip so that no adjustment is possible. The user varies the rate of cooling by adjusting the speed of the turbulence inducing fan(s) in each section which may be controlled in common or be individually controlled as desired.

For a better understanding of the present invention reference will now be made, by way of example to the accompanying drawings, in which:-

Brief Description of the Drawings

Figure 1 is a side view of one embodiment of a tunnel freezer in accordance with the invention;
Figure 2 is a section on line II-II of Figure 1;
Figure 3 is a vertical section through one module of the tunnel freezer taken on the line III of Figure 1;
Figure 4 is a top plan view showing a modification; and
Figure 5 is a graph showing the approximate temperature profile in the tunnel freezer in use.

Detailed Description of the Preferred Embodiments

Referring to Figure 1 of the drawings, there is shown a tunnel freezer which is generally identified by reference numeral 1.

The tunnel freezer comprises five modules 2, 3, 4, 5 and 6.

Modules 2, 3, 4 and 5 are identical whilst module 6 comprises an exhaust hood 7 connected to an exhaust duct 8 in which is mounted a variable speed extractor fan (not shown).

A conveyor 9 having an upper reach 10 and a lower reach 11 extends along the tunnel freezer 1 from product inlet 12 to product outlet 13.

Since the modules 2, 3, 4 and 5 are identical only module 3 will now be described in detail.

Referring to Figures 2 and 3, module 3 comprises a roof section 14 and a base section 15. The conveyor 9 is supported by structural members 16

and 17 which are welded to a sub-frame 18 which is supported by a main frame 19. The base section 15 is secured to the main frame 19 whilst the roof section 14 is slidably mounted on the main frame 19 and can be raised to the position shown in dotted lines in Figure 2 to allow access to the conveyor 9.

A cowl 20 is disposed below the conveyor 9. The cowl 20 opens below and to either side of the conveyor 9 and extends downwardly to the intake of a turbulence inducing fan 21 which is mounted on a drive shaft 22 which extends through the base section 15 of the tunnel freezer 1 and is provided with a drive pulley 23.

Passageways 24 are formed along each side of the tunnel freezer 1 between the cowl 20 and the inside of the base section 15 and part of the roof section 14.

The roof section 14 is provided with a deflector 25 which, in cross-section, is in the form of a cusp. A temperature sensor 26 is mounted on the cowl 20 and extends below the lower reach 11 of the conveyor 9 as shown.

A liquid nitrogen supply line 27 extends through the base section 15 and terminates in a nozzle beneath the turbulence inducing fan 21. Flow through the liquid nitrogen supply line 27 is controlled by a solenoid valve 28 which is either ON or OFF. Liquid nitrogen supply lines 29 and 30 extend through the roof section 14 and terminate in nozzles which open through the sides of the deflector 25 as shown. Flow through the liquid nitrogen supply lines 29 and 30 is controlled by a solenoid valve 31 which is either ON or OFF.

As shown in Figure 3, module 2 comprises a second turbulence inducing fan 32 which is mounted on a drive shaft 33 having a drive pulley 34. Both the turbulence inducing fans 21 and 32 can be rotated by a common variable speed motor 35.

A liquid nitrogen supply line similar to liquid nitrogen supply line 27 is associated with turbulence inducing fan 32 but, like liquid nitrogen supply line 27, cannot be seen in Figure 3 as it is disposed behind the drive shaft 33.

Similarly, liquid nitrogen supply lines similar to liquid nitrogen supply lines 29 and 30 are disposed in the roof section 14 above the turbulence inducing fan 32.

Modules 2, 3, 4 and 5 are intended to operate at -40 °C, -73 °C, -107 °C, and -140 °C respectively.

The operation of the tunnel freezer 1 will now be described.

At the commencement of operation the turbulence inducing fans in the modules 2, 3, 4 and 5 are brought up to their rated speeds. Also the exhaust fan in the exhaust duct 8 is adjusted to rotate quite slowly.

Liquid nitrogen is admitted to each module by opening the solenoid valves associated with each module. The speed of the fan in the exhaust duct 8 is adjusted to inhibit nitrogen vapour entering the workplace via product outlet 13 and product inlet 12.

As the temperature in each module reaches its preset level the solenoid valves in the module are closed and the speed of the turbulence inducing fans associated with the module is reduced to 5% of its rated value. This is sufficient to inhibit significant stratification. If the temperature in the module rises the solenoid valves in the roof section 14 are opened until the temperature returns to the desired level.

Once the modules 2, 3, 4 and 5 have all reached their desired temperature with the turbulence inducing fans idling the fan in the exhaust duct 8 is set on automatic control. In this mode the speed of the exhaust fan is regulated by an oxygen sensor in the exhaust duct 8 which regulates the speed of the fan so that the oxygen content is kept substantially constant at a value reflecting a small ingress of air through the product inlet 12.

If a large number of easily frozen products, such as hamburgers, are to be frozen the turbulence inducing fans are set to rotate at their rated speed. The work performed on the nitrogen vapour by the turbulence inducing fans warms the vapour and the solenoid valves 31 open and close to maintain the temperature at each temperature sensor substantially at its predetermined level.

As the hamburgers are introduced into the product inlet 12 they create a heat load which is met by the solenoids in the roof sections 14 opening as desired. If the heat load is too great then the solenoid valves in the base section 15 are opened and closed as desired.

The approximate temperature profile in the tunnel freezer 1 is shown in Figure 5.

The temperature of the frozen product leaving the product outlet 13 is monitored either by hand or with the use of an infra-red camera (not shown). If the product is too cold the speed of the turbulence inducing fans may be reduced. This may be effected by reducing the speed of all the turbulence inducing fans or only some. Conveniently, small amounts of excess cooling can be avoided by reducing the speed of the turbulence inducing fans in module 2.

When it is desired to freeze larger items, such as gateaux or turkeys, the speed of the turbulence inducing fans is set to about 40% of the normal speed. The turkeys are then passed through the tunnel freezer and emerge slightly colder than required. The speed of the turbulence inducing fans is then reduced incrementally until the frozen turkeys emerge at the desired temperature. The

speed of the turbulence inducing fans is then further reduced. Interestingly, this may have no effect on the temperature of the emerging turkeys since the freezing process may be controlled by the thickness of the turkey and the speed at which the freezing front travels across the turkey may not be enhanced by excess turbulence inducing fan speed. The speed of the turbulence inducing fans is reduced incrementally until the product leaving the freezer is warmer than required. At that time the speed of the turbulence inducing fans is increased until the desired product temperature is obtained.

It will be noted that the control of the freezing process described is totally different from known freezers. In particular, each section is maintained at a preset temperature throughout and the speed of the turbulence inducing fans is varied. Furthermore, each module has its own individual temperature control system and turbulence inducing fan speed control.

The tunnel freezer 1 thusfar described has the disadvantage that whilst the turbulence inducing fans direct some of the cryogenic fluid through the passageways 24 part is directed axially along the tunnel freezer 1. This is generally undesirable.

In order to reduce this problem, and to help divide the flow of cryogenic fluid equally between the passages 12 deflectors may be provided as shown in Figure 4. In particular, deflectors 36 are provided which are inclined upwardly from the base section 15 and away from the turbulence inducing fan with which they are associated as shown. Each deflector 36 is generally triangular in shape and extends from a tip 37 adjacent the base section 15 to the cowl 20 at its widest point. A cover plate 38 and the whole structure is filled with an insulator. The tips 37 are offset from the centre line of the tunnel freezer to help ensure that the cryogenic fluid is equally divided between the passageways 24.

The embodiment described also has useful safety implications. In particular, in the prior art it was not unknown for a customer to use excessive amounts of liquid nitrogen in an attempt to increase the throughput of his tunnel. This often resulted in liquid nitrogen lying in pools in the base of the tunnel. This, in turn, caused air to liquify in the insulation. When the tunnel was turned off the liquified air expanded explosively buckling the walls of the tunnel. The predetermined temperature control of the preferred embodiment obviates this problem.

Claims

1. A tunnel freezer (1) having at least one turbulence inducing fan (21, 32) and means (35) to drive said turbulence inducing fan (21, 32), characterized in that said tunnel freezer (1) further comprises means (35) to vary the output of said turbulence inducing fan.

2. A tunnel freezer as claimed in Claim 1, characterized in that said means (35) is capable of reducing the speed of said turbulence inducing fan (21, 32) to about 50% of its normal operating speed.

3. A tunnel freezer as claimed in Claim 2, characterized in that said means (35) is capable of reducing the speed of said turbulence inducing fan (21, 32) to about 30% of its normal operating speed.

4. A tunnel freezer as claimed in Claim 3, characterized in that said means (35) is capable of reducing the speed of said turbulence inducing fan (21, 32) to about 20% of its normal operating speed.

5. A tunnel freezer as claimed in Claim 4, characterized in that said means (35) is capable of reducing the speed of said turbulence inducing fan (21, 32) to about 5% of its normal operating speed.

6. A tunnel freezer as claimed in any preceding Claim, characterized in that it further comprises a control unit in which is programmed turbulence inducing fan speeds suitable for use with specific products.

7. A tunnel freezer as claimed in any preceding Claim, characterized in that it includes a height gauge for monitoring the height of product entering said tunnel freezer (1) and means for automatically adjusting the speed of said turbulence inducing fan(s) in response thereto.

8. A tunnel freezer as claimed in any preceding Claim, including at least one gas transfer fan for transferring gas along said tunnel freezer.

9. A tunnel freezer as claimed in any preceding Claim having at least two sections (2, 3, 4, 5), each section (3) having a temperature sensor (26), means (22, 29, 30) for supplying a cryogenic fluid to said section in response to said temperature sensor (26), at least one turbulence inducing fan (21, 32), and means (35) to adjust the speed of said turbulence inducing fan (21, 32).

10. A tunnel freezer as claimed in Claim 9, including four sections (2, 3, 4, 5).

11. A tunnel freezer as claimed in Claim 10, including control means for maintaining said sections at different temperatures when said tunnel freezer is in use.

12. A tunnel freezer as claimed in Claim 11, wherein said temperatures are -40 °C±5 °C, -73 °C±5 °C, -107 °C±5 °C, and -140 °C±5 °C.

13. A tunnel freezer as claimed in Claim 9, 10, 11 or 12, wherein said means for supplying a cryogenic fluid to said tunnel comprises a nozzle (22) arranged to supply a cryogenic fluid into the vicinity of said turbulence inducing fan.

14. A tunnel freezer as claimed in any of Claims 9 to 13, including a tunnel (1), a conveyor (9) extending along said tunnel, a turbulence inducing fan (21, 32) positioned below said conveyor (9), a cowl (20) disposed beneath said conveyor (9) and arranged to duct cryogenic fluid to said turbulence inducing fan (21, 32), a passageway (24) to either side of said turbulence inducing fan (21, 32) for ducting cryogenic fluid from said fan into a space above said conveyor, and a deflector (25) in the roof of said tunnel (1) for directing said cryogenic fluid from said turbulence inducing fan downwardly towards said conveyor, wherein said means for supplying a cryogenic fluid to said tunnel comprises a nozzle (29, 30) in or adjacent the roof of said tunnel (1).

15. A tunnel freezer as claimed in Claim 14, wherein said deflector (25) has, in cross-section, the shape of a cusp and a nozzle opens into said tunnel to either side of the tip of said cusp (25).

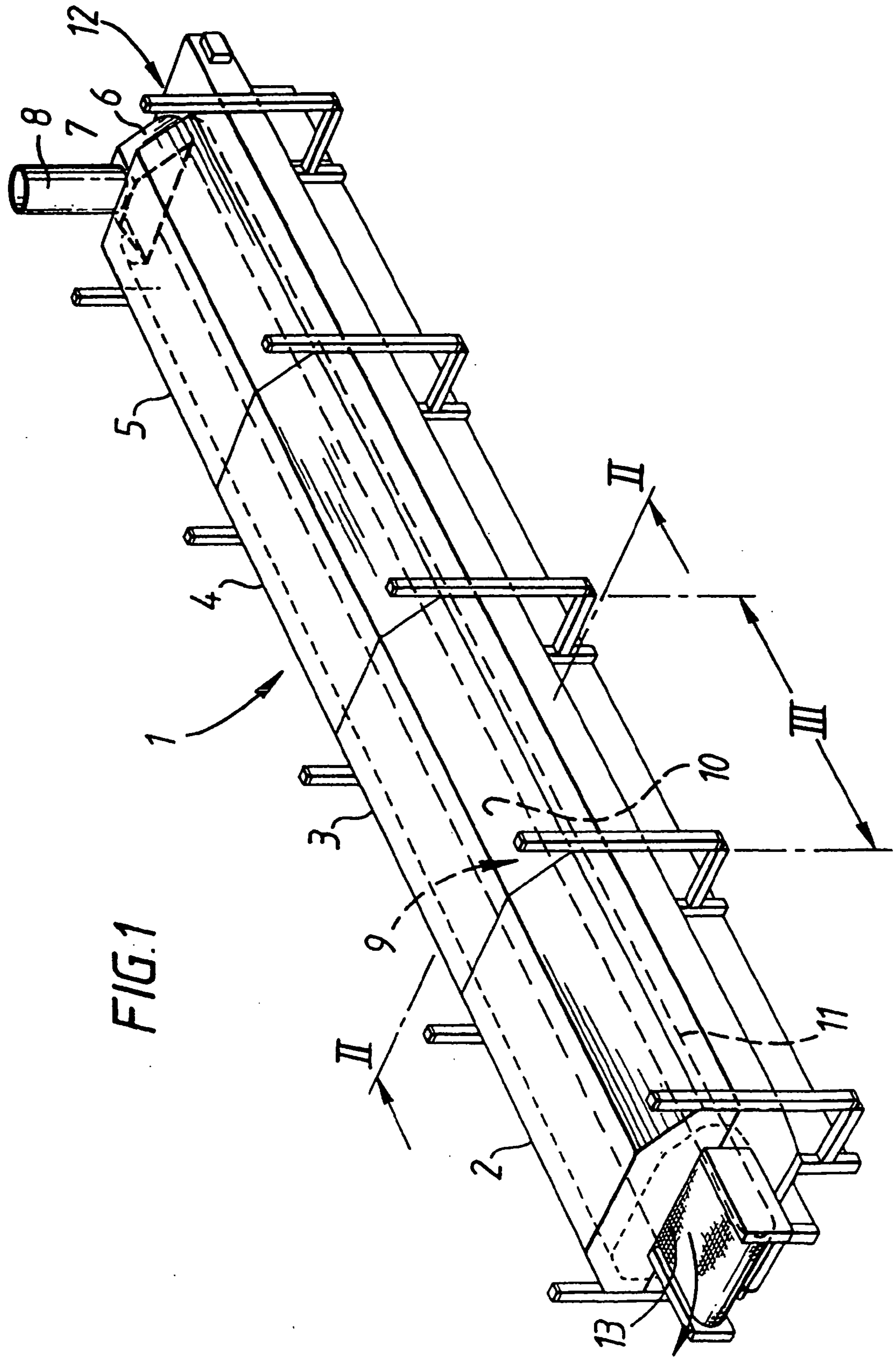
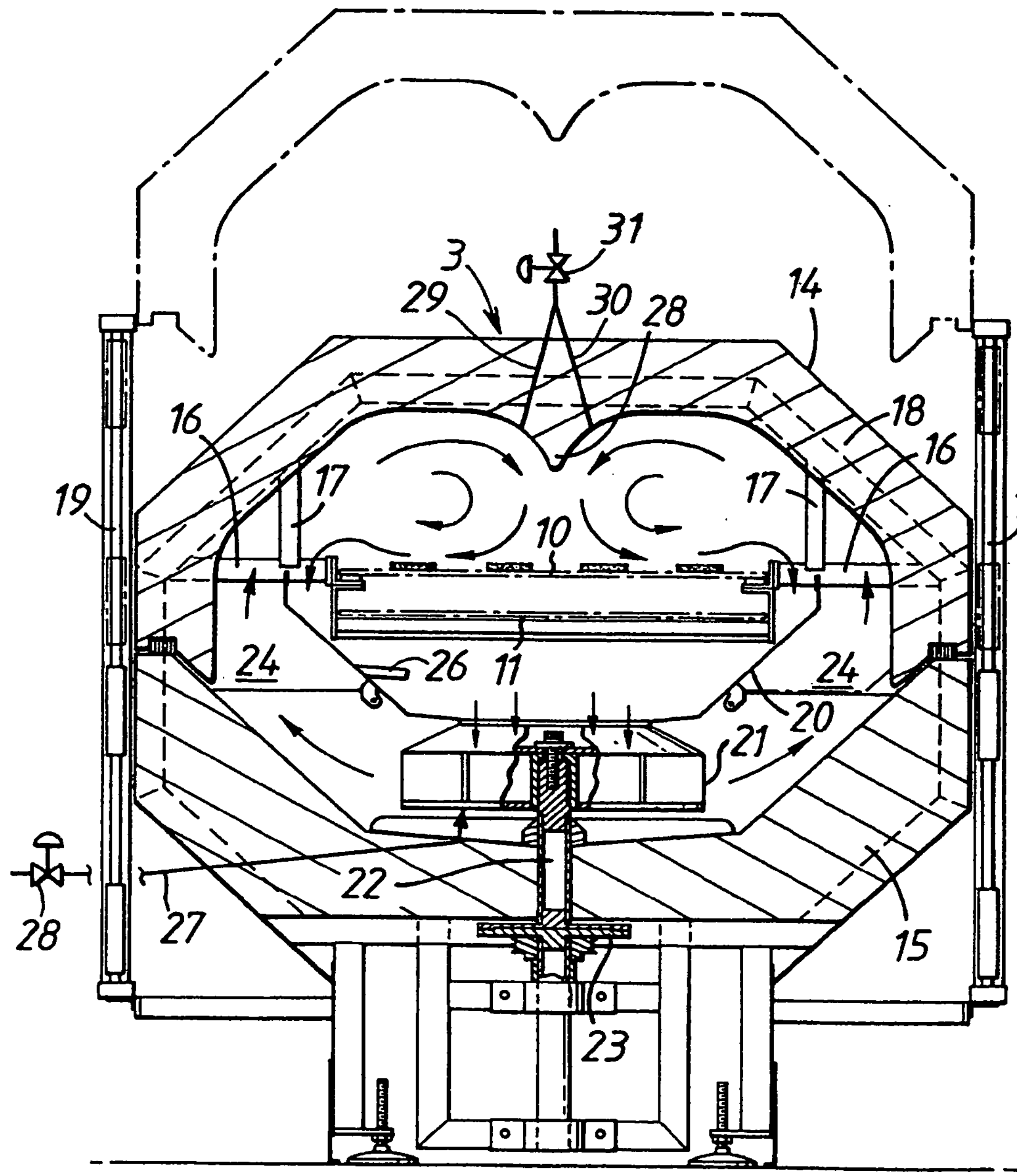


FIG.1

FIG.2



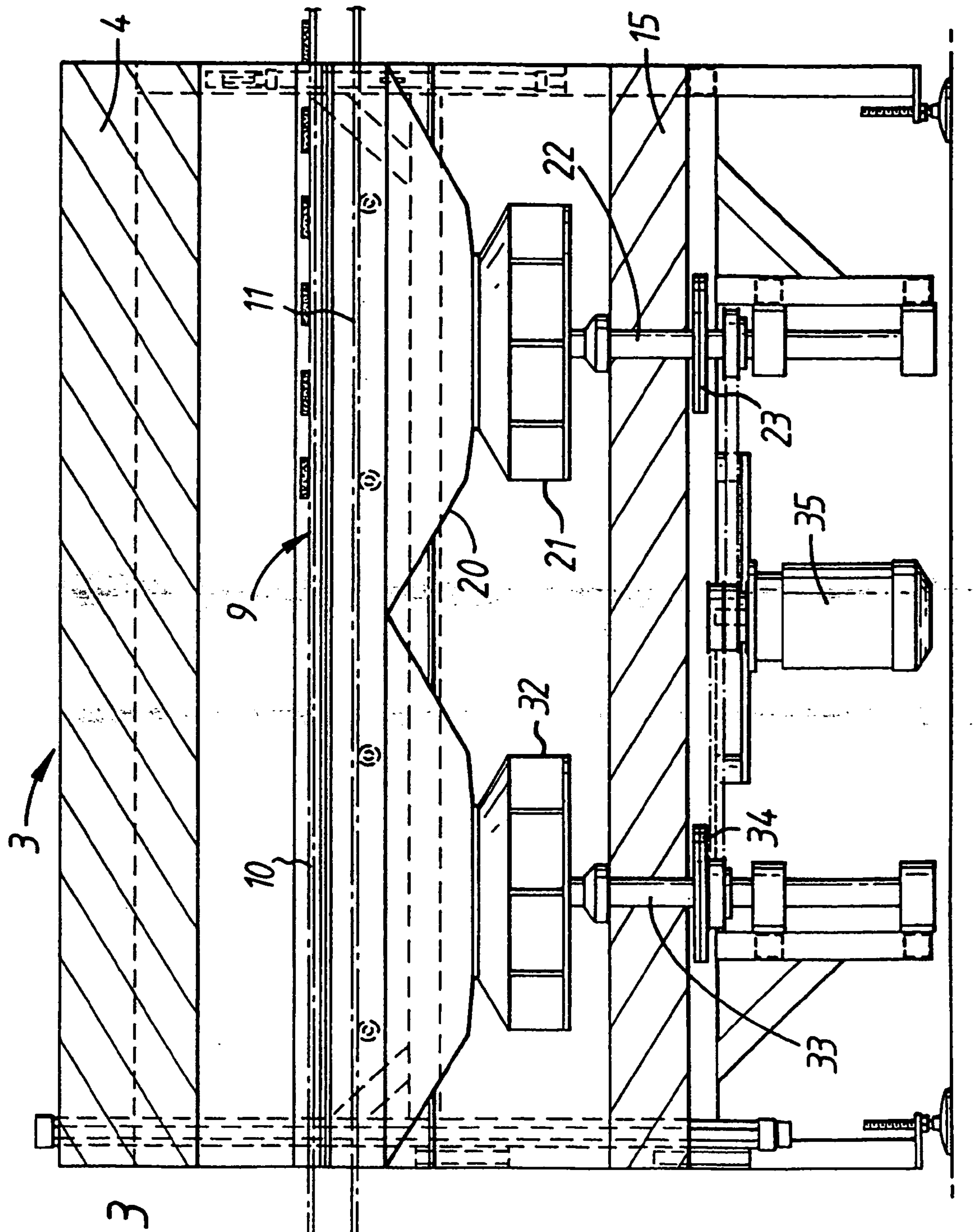


FIG.3

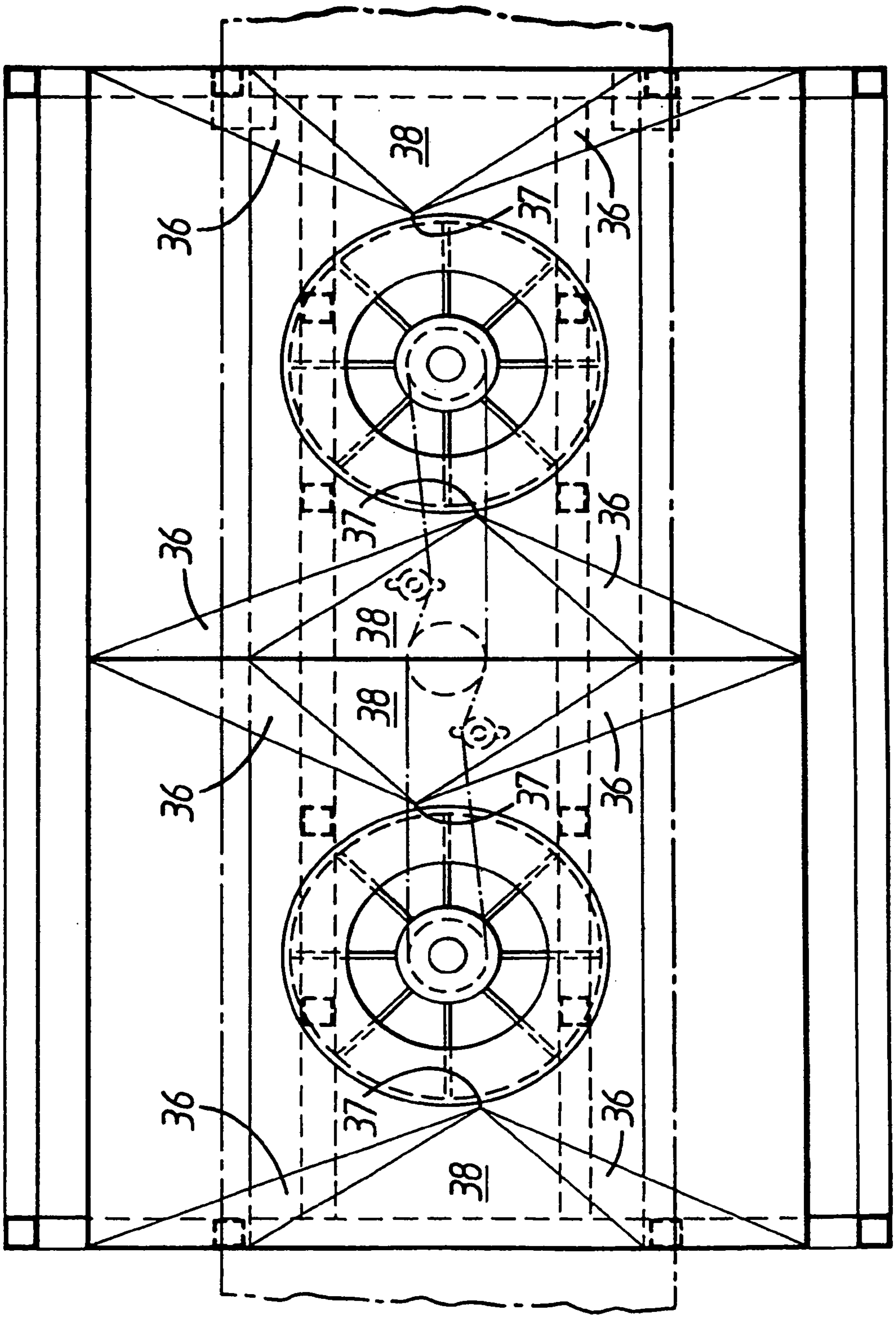
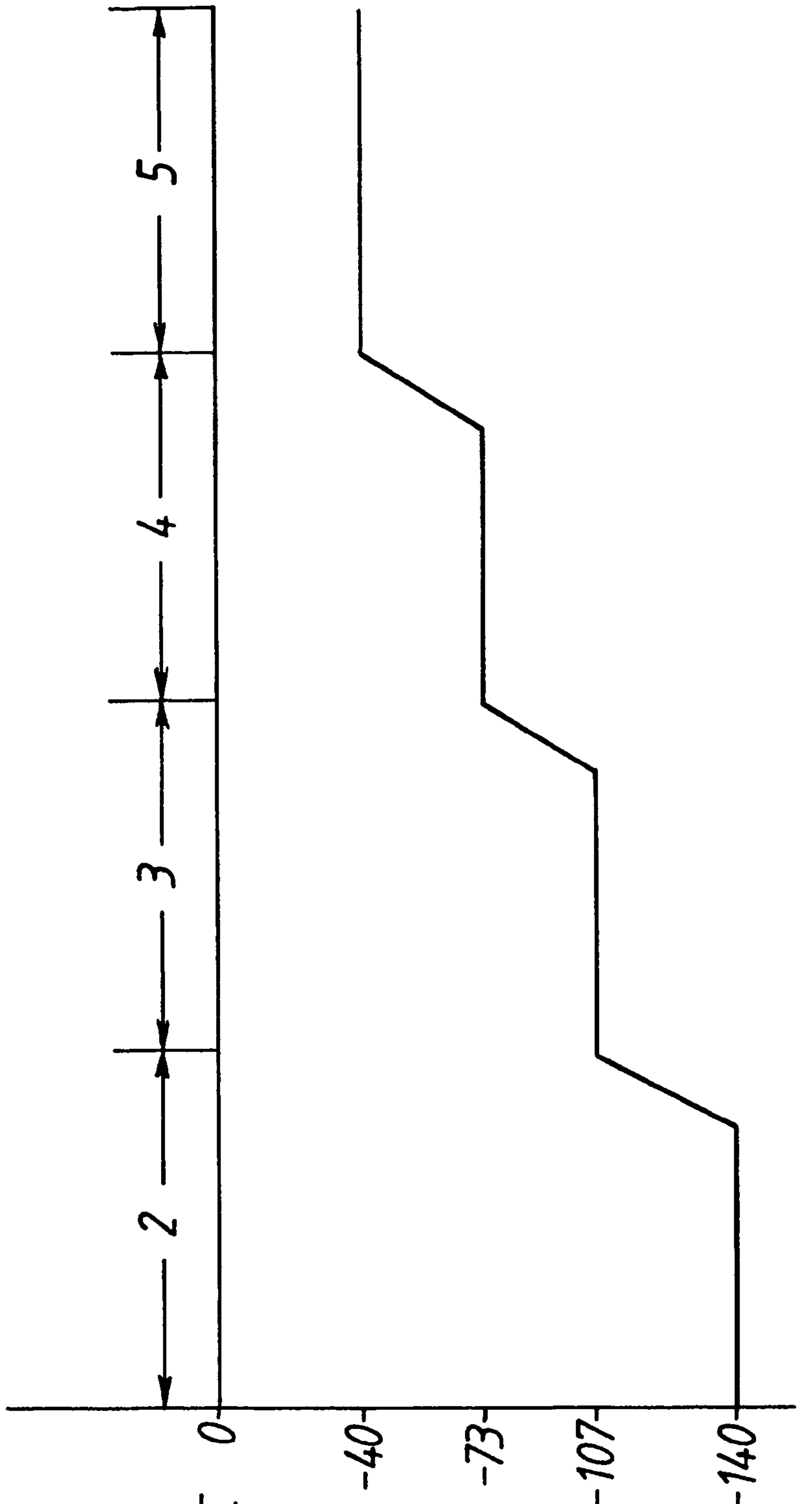


FIG. 4

FIG.5



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 10 2050

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US-A-4 912 943 (HUBERT JEAN-LUC ET AL) 3 April 1990 * column 5, line 62 - column 6, line 4 *	1-5	F25D3/11 A23L3/36 A23L3/375
Y		6,7, 9-11,13	
Y	US-A-4 934 151 (SHIMA YOSHISUKE) 19 June 1990 * column 4, line 10 - column 8, line 14; figures *	6,7, 9-11,13	
X	US-A-5 222 363 (ALLEN JR RUSSEL G ET AL) 29 June 1993 * column 3, line 62 - column 4, line 4; figure 1 *	1	
A		14	
A	FR-A-2 244 973 (AIR PROD & CHEM) 18 April 1975 * claim 1; figure 4 *	1-6,8	
A	US-A-4 276 753 (SANDBERG GLENN A ET AL) 7 July 1981 * column 7, line 33 - line 55; figure 1 *	1-5,8	TECHNICAL FIELDS SEARCHED (Int.Cl.6) F25D A23L
A	US-A-3 376 710 (HIRTENSTEINER WALTER EARL) * column 3, line 24 - line 60; figure 1A *	14,15	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 May 1995	Eccetto, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document